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Sidewall Effects of Wind Tunnel on Aeolian Sediment Transport

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Introduction

Wind tunnels are deployed for investigating aeolian sediment transport. But the sidewalls of wind tunnels may distort the measurements of aeolian sediment transport.

The width, or more general parameter--aspect ratio (width/height), of a wind tunnel is a major factor in determining if sidewalls effect will be important. Rasmussen and Mikkelsen (1991) presumed that sidewalls did influence wind measurements of Kawamura (1951) experiments conducted in a 5 cm wide wind tunnel. Horikawa and Shen (1960) and Belly (1964) suggested the sidewall effect on the velocity distribution could be ignored compared with a relative wide wind tunnel. Obviously, there needs to be more experimental data to explore the relation between the sidewall effect and the aspect ratio.

The aim of this short paper is to describe experimentally the sidewall effects of wind tunnel on wind velocity distributions and sand mass flux. The experiments were conducted in a wind tunnel, the aspect ratios of which can vary from 0.33 to 1.00.

Methods

The experiments were carried out in a straight-line blowing wind tunnel at the Shapotou Desert Research Station, Lanzhou Institute of Desert Research (Chinese Academy of Sciences). The tunnel body rests on the lab floor. The test section is 21 m long, 1.2 m high, and 1.2 m wide. The floor of the test section consists of seven panels, each one of which is 3 m long and can be removed to meet specific experiment needs. These panels were used as the added sidewalls of wind tunnel in the experiments (Fig.1). The widths of added sidewalls are 1 m, 0.8 m, 0.6 m and 0.4 m, respectively. The wind tunnel in the experiments had five aspect ratios (width/height) of 1.00, 0.83, 0.67, 0.50 and 0.33, respectively.

Wind velocities were measured with a single hack tube connected to a digital pressure meter that, in turn, was controlled by an IBM PC. Figure 2 shows the measurement positions of wind velocity. In Fig.2, y is the distance from the left wall, B the width of wind tunnel, z the height above the bed, and H the height of wind tunnel. A Liu's type passive vertical array sand trap (Liu, 1995), used to measure the vertical sand mass flux profiles, is 30 cm high and has 30 collection chambers. The aperture of each chamber is 1 cm wide and 1 cm high. The test sand was obtained from Tengger Desert in China. The mean grain diameter is 0.35 mm. To guarantee the same flux of wind flow in the experiments with different aspect ratios, the rotate speed of electric machine kept at 375 r.p.m. in all the runs.

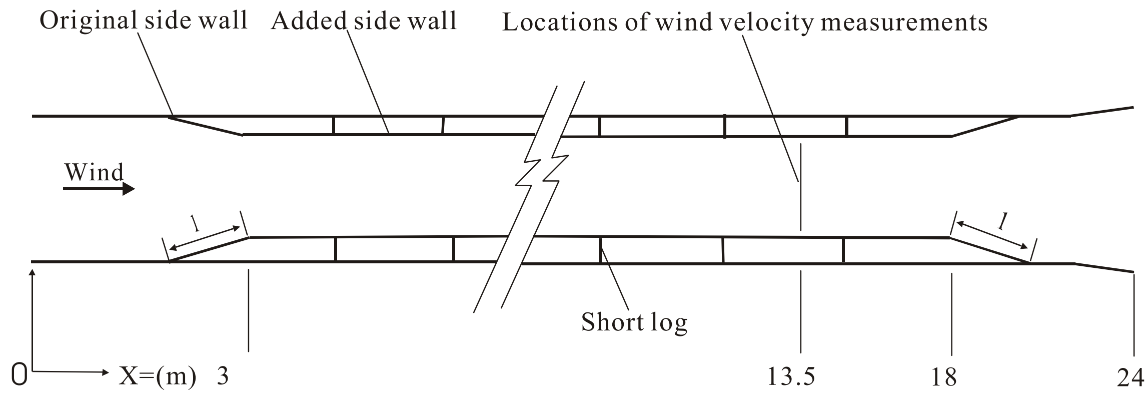

Figure 1. Schematic diagram of the wind tunnel used for the experiments (Dimensions are in m).

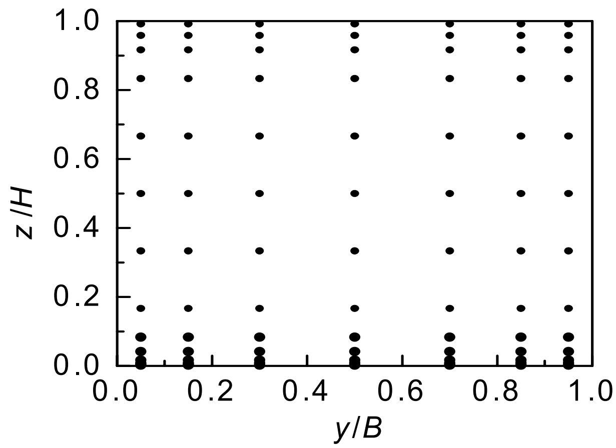

Figure 2. Locations of wind velocity measurements in a cross section of the wind tunnel.

Results and Discussion

The results of velocity for five aspect ratios are plotted in Fig. 3.The sidewall affects: (i) wind velocity field; (ii) upper-edge heights and wind velocity distribution of the inner saltation layer; (iii) effective roughness and upper-edge heights in the outer saltation layer; (iv) wind friction velocity in the cross sections;(v) free stream wind velocities; (vi) sand transport rate; and (vii) profiles of sand mass flux.

With the decrease of aspect ratio, the region where sidewall effects on wind velocity increase compared with the width of wind tunnel. The pattern of wind velocity isoline near the bed surface vary from W shape into beeline with the decrease of aspects ratio. The region of maximum wind velocity moves down with the decreasing aspects ratio.

In a cross section, the effective roughness corresponding to the central vertical profile is greater than those in other vertical profiles. The wind friction velocity as well as the upper-edge heights for velocity profiles in either inner or outer saltation regions increase from the sidewall to the central line of wind tunnel. Both the ratio of friction velocity to free stream wind velocity and the thickness of airflow are subject to the sidewall effect, showing the increase trend with the decreasing aspect ratios.

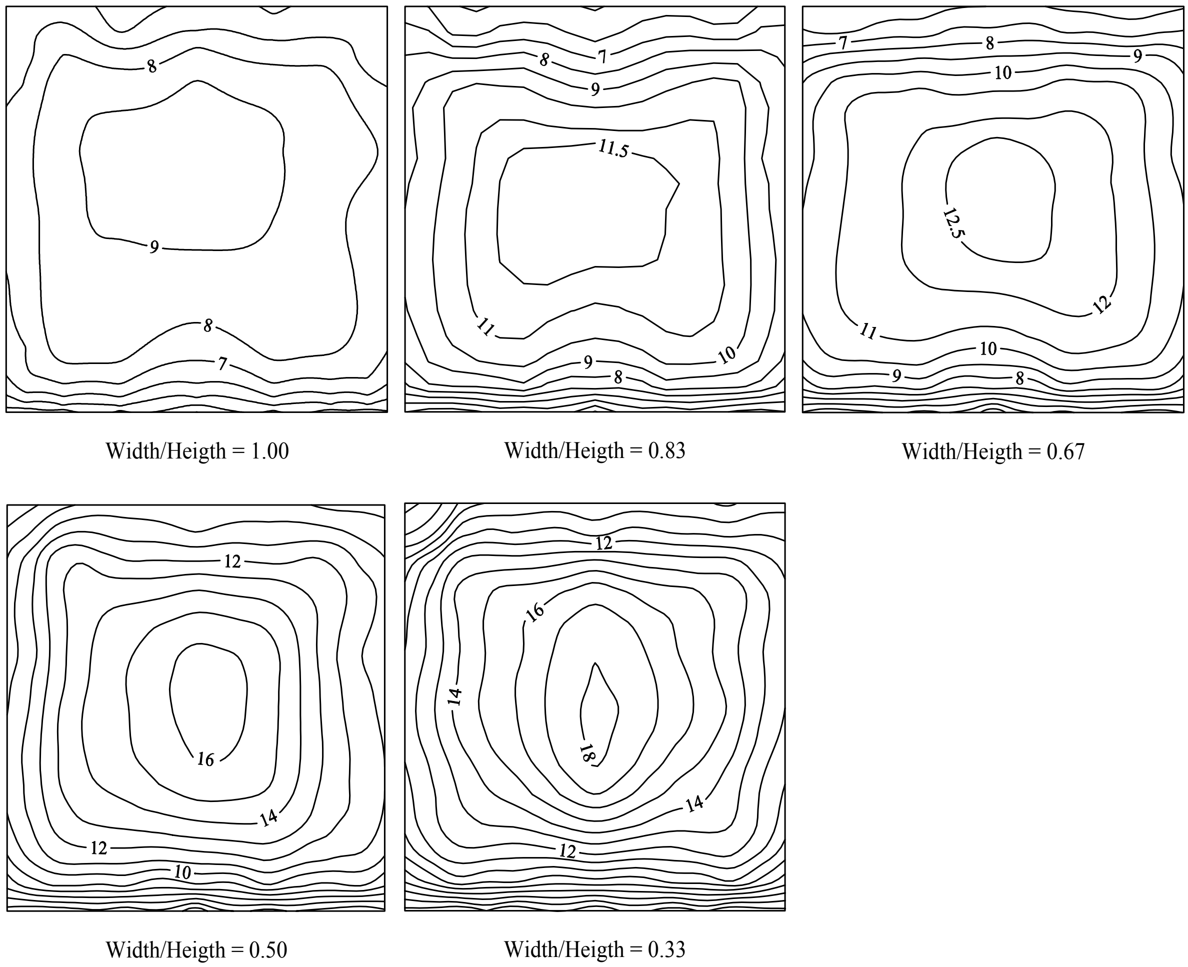

Figure 3. Cross sections of wind velocity at x = 13.5 for five aspect ratios of the wind tunnel.

The measurements of sand mass flux for four aspect ratios are shown in Fig. 4. The sand transport rates increase with the decreasing aspect ratio. Gradient of sand mass flux profiles in central line are less than ones in other lines in the wind tunnel.

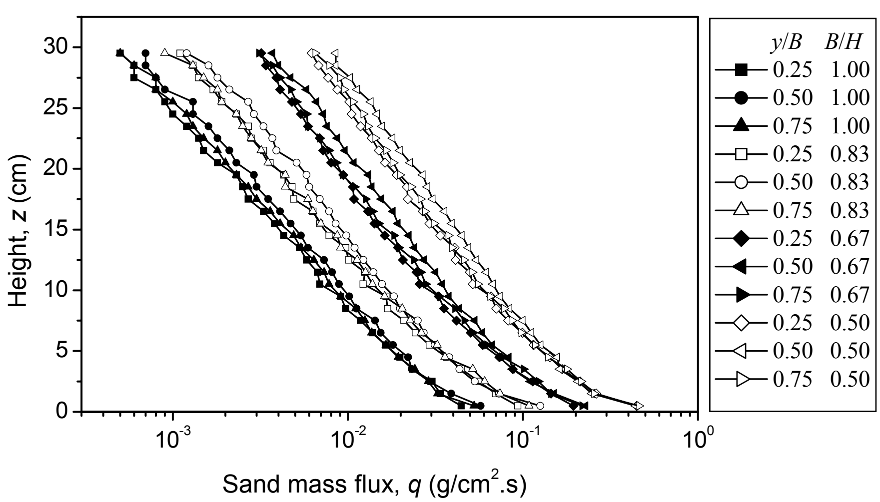

Figure 4. Measured sand mass fluxes in four wind tunnels.

Conclusions

The sidewall exerts significant effects on the parameters of vertical profiles of wind velocity and sand mass flux. The parameters are effective roughness, wind friction velocity, free stream wind velocity, sand transport rate, profiles gradient of sand mass flux etc. Sidewall effects should be taken into account especially for the wind tunnels with small aspect ratio.

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